

## **REDUCED SIZE EIGHT-PIN AUDIO JACK ELECTRICAL CONNECTOR**

The present application is a continuation-in-part  
5 of and claims priority of U.S. patent application  
Serial No. 10/072,753, filed February 8, 2003, the  
content of which is hereby incorporated by reference in  
its entirety.

### 10 FIELD OF THE INVENTION

This invention relates to electrical connectors  
for use with electronic devices, and more  
particularly, relates to an improved eight-pin audio  
connector and jack for use with electronic devices.

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### BACKGROUND OF THE INVENTION

Electronic devices such as wireless telephones,  
hand-held computers and personal digital assistants  
use a variety of power/data/audio connector/jack  
20 combinations for transferring power, data and other  
electrical signals to and from the electronic  
devices. For example, electronic devices equipped for  
audio input/output include an audio output jack for  
receipt of an audio connector for presenting audio  
25 output to a user. Prior art audio output connectors  
often include a four-pin stereo plug that can mate  
with and accept signals from standard four-pin stereo  
contacts and an additional four-pin plug arranged  
adjacent to the four-pin stereo plug for additional

electrical connectivity. The physical size associated with such prior art connectors becomes relatively large compared to modern electronic devices that are very small and lightweight. Consequently, the audio  
5 plug becomes obtrusive and cumbersome, and often contact between the connector and the electronic device is difficult to maintain.

Additionally, modern electronic devices, such as personal digital assistants, include jacks for other  
10 types of connectors, such as power connectors and universal serial bus (USB) connectors. Prior art systems include a USB connector for mating to a USB jack and a separate power connector for mating to a power jack. As is often the case, a user of a  
15 personal digital assistant may have a number of connectors attached to the personal digital assistant at any given time. That is, the user may have an electrical connector for providing audio signals to a speaker device, the user may have a USB connector  
20 connected to the personal digital assistant for transferring data to and from the personal digital assistant, and the user may have a power connector connected to the PDA for providing electrical power. The problem with this arrangement is that the mass of  
25 the various cords and connectors attached to the personal digital assistant often overwhelm the mass of the personal digital assistant and thus places strain on the various connectors and jacks which may cause damage to the connectors and jacks and which

may make use of the personal digital assistant cumbersome.

It is with respect to these and other considerations that the present invention has been  
5 made.

#### SUMMARY OF THE INVENTION

In accordance with the present invention, the above and other problems are solved by an improved  
10 electrical connector and an improved USB connector.

According to one aspect of the present invention, an improved electrical connector includes a main connector housing having an upper pin housing and a lower pin housing. The upper pin housing has an  
15 outer surface and an inner surface where the outer surface forms a continuous surface with the surface of the main connector housing. The upper housing has a pair of electrical contact pins disposed along the inner surface of the upper housing.

20 The lower pin housing is disposed in spaced-apart relation to the upper pin housing, and the lower pin housing has an outer surface and an inner surface, where the outer surface forms a continuous surface with the surface of the main connector  
25 housing. The inner surface of the lower pin housing faces the inner surface of the upper pin housing. The lower pin housing has a pair of electrical contact pins disposed along the inner surface of the lower pin housing. The electrical connector of the present  
30 invention also includes a stereo plug that protrudes

from a front surface of the main connector housing between the inner surface of the lower pin housing and the inner surface of the upper pin housing.

5       The electrical connector is adapted to connect to a jack. The stereo plug of the electrical connector is adapted to connectively insert into a plug port of the jack. The upper pin housing and the lower pin housing are adapted to connectively engage a forward plug port housing of the jack.

10       The stereo plug includes a plurality of electrical contact pins for engaging a corresponding plurality of electrical contacts disposed along an interior surface of the plug port of the jack. The pair of electrical contact pins of the upper housing  
15       engage a corresponding pair of electrical contacts disposed along an upper surface of the forward section of the plugged port housing of the jack. The pair of electrical contact pins of the lower housing likewise engages a corresponding pair of electrical  
20       contacts disposed along the lower surface of the forward section of the plug port housing.

      The stereo plug has a plurality of contact pins. The contact pins of the stereo plug may include a microphone contact, a right speaker contact, a left  
25       speaker contact, and an analog ground contact. The pair of electrical contact pins of the upper housing may include a clock contact pin and a digital ground pin. The pair of electrical contact pins of the lower housing may include a data pin and a power pin.

The jack of the present invention is mounted within the casing of an electronic device such as a hand-held personal computer, a personal digital assistant, a wireless telephone, or a paging device.

5 A face surface of the forward section of the jack is flush with an exterior surface of the casing of the electronic device. An upper housing receiving port is defined in the casing immediately above the upper surface of the forward section of the jack. A lower  
10 housing receiving port is defined in the casing immediately below the lower surface of the forward section of the jack. When the electrical connector is connected to the jack, the upper pin housing is inserted into the upper housing receiving port and  
15 the lower pin housing is inserted into the lower housing receiving port so that the electrical connector is mated to the casing of the electronic device.

According to another aspect of the present  
20 invention, an improved electrical connector and jack is provided with a narrower profile. The electrical connector includes a main connector housing and a stereo plug protruding from a front surface of the main connector housing. A first pair of electrical  
25 contact pins is supported by the main connector housing on a first side of the stereo plug, and a second pair of electrical contact pins is supported by the main connector housing on a second side of the stereo plug opposite the first side of the stereo  
30 plug. An alignment feature protrudes from the front

surface of the main connector housing adjacent the stereo plug, providing orientation key and anti-rotation functions to be provided with a narrower profile.

5           According to another aspect of the present invention, an improved USB connector includes a connector body, a USB connector plug, and an alignment post. The USB connector plug is defined along a first end of the connector body and protrudes  
10           perpendicularly from a front face of the connector body. The alignment post is defined adjacent to the USB connector plug in spaced-apart relation to the USB connector plug and protrudes perpendicularly from the front face of the connector body. The USB  
15           connector also includes a pair of electrical contacts defined on the face of the connector body. A first electrical power contact of the pair of electrical contacts is disposed adjacent to a first side of the alignment post, and a second electrical contact of  
20           the pair of contacts is disposed on the face of the connector body immediately adjacent to a second side of the alignment post.

          The USB connector plug is adapted for connectively inserting into a mating plug port of a  
25           USB jack. The alignment post is adapted to connectively insert into a corresponding alignment post port of the USB jack. The first and second electrical power contacts are adapted to engage corresponding first and second electrical power input

contacts defined adjacent to first and second sides of the alignment post port of the USB jack.

The alignment post includes an alignment post guide member that is disposed along the first side of the alignment post for guiding the alignment post into the alignment post port. The alignment post has a greater length than the USB connector plug so that the alignment post inserts into the alignment post port prior to insertion of the USB connector plug into the USB connector plug port to insure that the USB connector plug is in a proper orientation when it is inserted into the USB connector plug port. A locking latch may be disposed along an upper surface of the alignment post for engaging a locking latch detent disposed in an interior upper surface of the alignment post port for securing the USB connector to the USB connector jack.

These and other features which characterize the present invention will be apparent from a reading of the following detailed description and a review of the associated drawings. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only, and are not restrictive of the invention, as claimed.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side elevation view of an illustrative prior art eight-pin audio connector and corresponding jack.

Figure 2 is a perspective view of an eight-pin electrical connector and jack according to an embodiment of the present invention.

Figure 3 is a perspective pictorial view of an  
5 eight-pin electrical connector according to an embodiment of the present invention.

Figure 4 is a perspective pictorial view of a jack according to an embodiment of the present invention.

10 Figure 5 is a perspective pictorial view of a personal digital assistant showing an exterior case of the personal digital assistant in phantom and illustrating a jack and mini-USB connector of the present invention.

15 Figure 6 is a top-plan view of a personal digital assistant showing an eight-pin electrical connector according to an embodiment of the present invention.

Figures 7-1 and 7-2 are perspective views of an  
20 eight-pin electrical connector and jack, respectively, according to another embodiment of the present invention.

Figures 8-1 and 8-2 are perspective views of the  
eight-pin electrical connector and jack,  
25 respectively, shown in Figures 7-1 and 7-2.

Figure 9 is a perspective view of the eight-pin electrical connector and jack in accordance with the alternate embodiment of the present invention.

Figure 10 is a top-plan view of a personal  
30 digital assistant showing an eight-pin electrical

connector in accordance with the alternate embodiment of the present invention.

Figure 11 is a side view of personal digital assistants or other electronic devices having jacks  
5 in accordance with the embodiments of the present invention.

Figure 12 is a pictorial perspective view of a mini-USB connector plug and a mini-USB connector jack according to an embodiment of the present invention.

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#### DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The following description of embodiments of the present invention is made with reference to the above-described drawings wherein like numerals refer  
15 to like parts or components throughout the several figures. The present invention is directed to an improved eight-pin electrical connector and to an improved USB connector that includes an integrated power connector so that a separate power cord is not  
20 required.

Figure 1 is a side elevation view of an illustrative prior art eight-pin audio connector and corresponding jack. The illustrative prior art eight-pin audio connector 50 illustrated in Figure 1 is  
25 adapted to mate with a jack 65. The prior art connector 50 includes a four-pin stereo plug 55 and an additional four-pin plug 60 for additional electrical connectivity. The four-pin stereo plug 55 is adapted to mate with the jack port 70 and the  
30 four-pin plug 60 is adapted to mate with the jack

port 80 and contacts 85. A cord 52 is adapted to the rear section of the prior art connector 50. When the prior art connector 50 is mated with the prior art jack 65, forces placed on the connection by the weight of the connector 50 and cord 52 often place extensive strain on the electrical connections between the plugs 55, 60 and the corresponding jack ports 70, 80. Over time, the connections become worn and electrical connectivity may be disrupted or lost. Additionally, due to the size of the prior art connector 50 compared to modern small and lightweight electronic devices, such as wireless telephones and personal digital assistants, the weight and size of the connector and cord may overwhelm the weight and size of the electronic device to which they are connected to add further stress on the connections between the prior art connector 50 and an electronic device to which it is connected.

Figure 2 is a perspective view of an eight-pin electrical connector and jack according to an embodiment of the present invention. As shown in Figure 2, an improved eight-pin electrical connector 100 is adapted for mating with a jack 200. The eight-pin electrical connector 100 includes a cord 190 disposed along an upper surface of the eight-pin electrical connector 100. As should be understood by those skilled in the art, the cord 190 may be placed along other surfaces or sides of the eight-pin electrical connector 100 as desired. Protruding from a front side of the eight-pin electrical connector

100 is a four-pin stereo plug 105. Description of the connector 100 for use in audio connections is by way of example only and is not limiting of the types of connections for which the connector 100 may be used.

5 The connector 100 of the present invention may be used as a vehicle for a variety of connection pins to corresponding contacts of a mating jack. For example, the connector 100 may be used to transfer data to and from an electronic device via a connection between  
10 the connector and a mating jack such as the jack 200 described below.

According to the exemplary audio connector illustrated in Figs. 2 - 4, the four-pin stereo plug 105 may include a microphone contact 110, a right  
15 speaker contact 120, a left speaker contact 130, and an analog ground contact 140. Disposed between the contacts 110, 120, 130 and 140 are a plurality of insulators 180. As set forth above the contacts 110, 120, 130 and 140 may be used for a variety of other  
20 types of electrical and data connectivity.

Above and below the four-pin stereo plug 105 are an upper pin housing 170 and a lower pin housing 172, respectively. As shown in Figure 1, the lower pin housing 172 includes a pair of additional electrical  
25 pins, for example, a data pin 150 and a power pin 160. Referring to Figure 3, for a different view of the eight-pin electrical connector 100, the upper pin housing 170 includes additional electrical pins, for example, a clock pin 192 and a digital ground pin  
30 196.

A jack 200 according to an embodiment of the present invention is illustrated in Figures 2, 4 and 5. The jack 200 includes a number of contacts for establishing electrical connectivity with the pins of the eight-pin electrical connector 100. As described above with reference to the connector 100, the contacts of the jack may be used for a variety of electrical or data connections with the connector 100. By way of example, as shown in Figure 2, a pendant bus clock contact 210 and a pendant bus ground contact 220 are disposed along an outer surface of the forward end of the jack 200 for electrically mating with the contacts 192 and 196 of the eight-pin electrical connector 100. Additional contacts may include a microphone input contact 230, a speaker pass-through contact 240, a right speaker contact 250, a pendant bus clock contact 260, an analog ground for audio signals contact 270, and a pendant bus ground contact 280.

Figure 4 is a perspective pictorial view of a jack according to an embodiment of the present invention. A number of other contacts are disposed along the other side of the jack 200 and may include, for example, a pendant bus power contact 215 and a pendant bus ground contact 220 for electrically connecting to the pins 150 and 160 of the connector 100, illustrated in Figure 2. Additional contacts of the jack 200 may include a pendant bus power contact 265, a left speaker contact 275, a pendant bus open collector data contact 285, and a microphone pass-

through contact 295. Electrical connectivity between the pins of the eight-pin electrical connector 100 and the contact of the jack 200, and operation thereof, is well known to those skilled in the art.

5        Figure 5 is a perspective pictorial view of a personal digital assistant showing an exterior case of the personal digital assistant in phantom and illustrating a jack 200 of the present invention integrated with the personal digital assistant 300.

10       The jack 200 is integrated with the personal digital assistant (PDA) 300 such that the front face 245 of the jack 200 is flush with the outer surface of the casing (shown in phantom) of the PDA 300. An upper housing receiving port is adapted into the casing of

15       the PDA 300 directly above the upper edge 248. A lower housing receiving port is adapted directly below the lower edge 249 of the jack 200. The receiving ports allow for insertion of the upper and lower pin housings 170, 172 of the eight-pin

20       electrical connector 100, illustrated below with reference to Figure 6.

Referring now to Figures 1, 3, 5 and 6, the eight-pin electrical connector 100 is adapted for mating with the jack 200 so that the four-pin plug

25       105 is inserted into the entry port 235 of the jack 200 until the front surface 141 of the main connector housing comes into snug contact with the front face 245 of the jack 200. When the eight-pin electrical connector 100 is connected to the jack 200, the upper

30       contact housing 170 slides over the upper edge 248 of

the forward section 247 of the jack 200. The lower contact housing 172 slides over the lower edge 249 of the forward section 247 of the jack 200. Thus, the pins 192 and 196 of the upper contact housing 170  
5 engage the electrical contacts 210 and 220 of the jack 200, and the pins 150 and 160 of the lower contact housing 172 of the eight-pin electrical connector 100 engage the contacts 215 and 225 of the lower edge 249 of the forward section 247 of the jack  
10 200.

Referring to Figure 5, when the eight-pin electrical connector 100 is connected to the jack 200, as described, the upper and lower contact housings 170, 172 are inserted into the receiving  
15 ports integrated within the casing of the PDA 300 in order for the pins 150, 160, 192, 196 to engage the corresponding contacts of the jack 200. Advantageously, insertion of the upper and lower pin housings 170, 172 into the casing of the PDA 300 in  
20 order to achieve electrical contact between all pins of the eight-pin electrical connector 100 with corresponding contacts of the jack 200 creates a secure fit between the eight-pin electrical connector 100 and the jack 200 and corresponding electronic  
25 device (for example, the PDA 300) in which the jack 200 is integrated.

The illustration in Figure 6 shows a cutaway section of the PDA 300 for illustration of the insertion of the four-pin plug 105 and the upper and  
30 lower pin housings 170 and 172 into the PDA 300 (jack

200 not illustrated in Figure 6). The upper and lower pin housings 170 are inserted into the interior of the PDA 300 so that the eight-pin electrical connector 100 achieves a secure connection with the jack 200 integrated interior of the PDA 300. In contrast to the prior art connector 50 illustrated in Figure 1, stresses placed on the eight-pin electrical connector 100 from contact with foreign objects or from the mass of the eight-pin electrical connector 100 and cord 190 relative to the PDA 300 place very little stress on the electrical connections between the pins of the eight-pin electrical connector 100 and the contacts of the jack 200. Insertion of the upper and lower pin housings 170 and 172 into the casing of the PDA 300 insures that vibration and stresses acting on the connection between the eight-pin electrical connector 100 and the jack 200 are not directed to the electrical contacts, but instead are directed to the housing of the eight-pin electrical connector 100 and the casing of the PDA 300 which are stronger and less likely to be damaged by the introduction of stresses applied to those components.

Additionally, by placing the additional four-pin contacts of the connector 100 inside the upper and lower housings 170, 172, the overall size and shape of the eight-pin electrical connector 100 is minimized relative to prior art connectors, such as the connector illustrated in Figure 1. As illustrated in Figure 6, the cord 190 is disposed along the upper surface of the eight-pin electrical connector 100.

This orientation is advantageous if the electronic device 300 is a personal digital assistant, wireless telephone, or other audio output device that may be carried in a shirt pocket or connected to a belt or  
5 other location, where an upward orientation of the cord 190 reduces additional strain on the connection between the eight-pin electrical connector 100 and the jack 200 integrated into the device 300.

Figures 7-1 and 7-2 are perspective  
10 illustrations of connector 100 and jack 200 which show alignment features which ensure that connector 100 can only be mated with jack 200 in a correct orientation. As can be seen in Figure 7-1, alignment or key features 702 and 704 extend from upper pin  
15 housing 170 in a direction which is generally toward lower pin housing 172. In order to insert four-pin stereo plug 105 into entry port 235 of jack 200 far enough for the pins on the upper and lower pin housings to engage electrical contacts on jack 200 as  
20 described above, alignment features 702 and 704 must be matched with alignment grooves 706 and 708 formed in forward section 247 of the jack. This prevents the pins on connector 100 from engaging the wrong contacts on jack 200, thereby preventing potential  
25 damage to electrical components.

Figures 8-1, 8-2 and 9 are perspective  
illustrations of a connector 750 and a jack 800 in  
accordance with an alternate embodiment of the  
present invention. With the exception of alignment or  
30 key features included on connector 750 and jack 800

to ensure correct orientation of the connector relative to the jack while providing a reduced profile or slimmer connector and jack design, connector 750 and jack 800 have the same features as described above with reference to connector 100 and jack 200. Connector 750 includes an upper pin housing 770 and a lower pin housing 772. Like the upper pin housing of connector 100, upper pin housing 770 of connector 750 supports pins 192 and 196. Likewise, like the lower pin housing of connector 100, lower pin housing 772 of connector 750 supports pins 150 and 160. However, neither of upper pin housing 770 and lower pin housing 772 includes the alignment features (i.e. alignment features 702 and 704 shown in Figure 7-1) for ensuring that connector 750 engages jack 800 with the correct orientation. Instead, an alignment feature or key 752 protrudes from front surface 141 of the main connector housing.

In some embodiments, alignment feature 752 protrudes from the front surface of the main connector housing adjacent to stereo plug 105. As such, alignment feature 752 extends from front surface 141 in a direction away from the front surface which is substantially parallel to a longitudinal axis 754 along which stereo plug 105 protrudes. In some embodiments, alignment feature 752 is positioned between stereo plug 105 and electrical contact pins 150 and 160, or between stereo plug 105 and electrical contact pins 192 and 196. In other words, this alignment feature also extends away from

the stereo plug along a longitudinal direction of the front surface 141 of the main connector housing. By forming the alignment feature 752 adjacent plug 105 in a center portion of front surface 141 of connector 5 750, the connector can be made considerably narrower than prior art eight-pin connectors. Further, it has been found that the design of connector 750 allows it to be approximately 30% narrower than the design of even connector 100 of the present 10 invention.

Alignment feature or key 752 can be made of a number of different materials, in addition to being moved to different positions along front surface 141 between upper pin housing 770 and lower pin housing 15 772. For example, if desired, alignment feature or key 752 can be a metal alignment feature. In these embodiments, if desired, alignment feature or key 752 can be formed integrally with one of the electrical contacts of plug 105. For example, alignment feature 20 or key 752 could be formed integrally with analog ground contact 140 if desired. In other embodiments, alignment feature 752 is formed from an insulating material such as plastic. In these embodiments, if desired, alignment feature 752 can be formed 25 integrally with the insulator 180 formed closest to front surface 141.

As can be seen in Figures 8-2 and 9, jack 800 in accordance with these alternate embodiments of the present invention includes a front face 845 in which 30 entry port 235 is formed. To ensure that pins 150,

160, 192 and 196 of connector 750 engage the correct ones of contacts 210, 215, 220 and 225 of jack 800, front face 845 also includes an alignment groove formed contiguously with entry port 235. When  
5 connector 750 is mated with jack 800, plug 105 can only be inserted into entry port 235 far enough for the pins of connector 750 to engage the contacts of jack 800 if alignment feature 752 is positioned such that it enters alignment groove 850. In one example  
10 embodiment, while jack 200 would have a width of approximately 5.7 mm, jack 800 would require a width of only 4 mm. This allows connector 750 and jack 800 to be used with slimmer electronic products such as flip phones. In addition to allowing connector 750  
15 and jack 800 to be thinner relative to connector 100 and jack 200 and relative to prior art eight-pin connectors and jacks, the alignment feature configuration on connector 750 and jack 800 provides more robust anti-rotation function.

20 The illustration in Figure 10 shows a cut-away section of a PDA (or other electronic device) 900 for illustration of the insertion of the four-pin plug 105 and the upper and lower pin housings 770 and 772 into the PDA 900 (jack 800 not illustrated in Figure  
25 10). The upper and lower pin housing 770 and 772 are inserted into the interior of the PDA 900 so that the eight-pin electrical connector 750 achieves a secure connection with the jack 800 integrated interior of the PDA 900. Alignment feature 752 both ensures that  
30 connector 750 is inserted with the correct

orientation of the upper and lower pin housings, and helps to prevent rotation of connector 750 relative to PDA 900. This in turn helps to prevent damage to the pins of connector 750 and the contacts of jack  
5 800.

Figure 11 is a side view illustration of PDA 300 including jack 200, and of PDA 900 including jack 800. As can be seen diagrammatically in Figure 11, jack 800 including alignment groove 850 has a width  
10 (represented by arrow 902) which is significantly less than the corresponding width (represented by arrow 904) of jack 200 which includes alignment grooves 706 and 708. Again, this provides opportunity for jack 800 to be used on even thinner electronic  
15 devices than would be possible with prior art eight-pin electrical connectors and jacks.

Figure 12 is a pictorial perspective view of a mini-USB connector plug and a mini-USB connector jack according to an embodiment of the present invention.  
20 The USB connector plug 500 illustrated in Figure 12 includes a printed circuit board 510 connected to a plug main body 505. Along a front surface of the plug main body 505 is a mini-USB connector plug 530 for passing data to and from an electronic device, such  
25 as a personal digital assistant 300. Adjacent to the USB connector plug 500 is an alignment post 525. Disposed on an upper surface of the alignment guide 525 is a locking latch 540. An alignment post guide 550 is defined along an inner side of the alignment  
30 post 525 for guiding the alignment post 525 into an

alignment post port 565. On each side of the alignment post 525 is an electrical power contact 530.

Opposite the USB connector plug 500 is a USB  
5 jack 555. The USB jack 555 includes a USB connector  
plug port 565 for receipt of the USB connector plug  
520 and an alignment post port 590 for receipt of the  
alignment post 525. A pair of electrical contacts 595  
and 596 are defined along each side of the alignment  
10 post port 590 for engagement with the power contacts  
530 defined along each side of the alignment post  
525. Interior of the alignment post port 590 is a  
locking latch detent for engagement with the locking  
latch 540 when the USB connector plug 500 is  
15 connected to the USB jack 555. A separate power jack  
575 with a power jack port 580 is disposed adjacent  
to the alignment post port 590 for connection of a  
separate electrical power contact to an electronic  
device in which the USB jack assembly 555 is  
20 integrated.

As illustrated in Figure 12, the alignment post  
525 has a greater length than the USB connector plug  
520 so that the alignment post 525 engages the  
alignment post port 590 before the USB connector plug  
25 520 engages the USB connector plug port 565. This  
configuration allows the alignment post 525 to place  
the plug assembly 505 in a proper orientation before  
introduction of the connector plug 520 into the  
connector plug port 565. As is well known to those  
30 skilled in the art, small connector plugs, such as

the mini-USB connector plug 520 are fragile and can become damaged if proper alignment of the connector plug to the connector plug port is not maintained during connection of the plug to the corresponding  
5 port.

Advantageously, use of the improved USB connector 505 of the present invention allows for the transfer of data via the connector plug, in addition to the transfer of electrical power, utilizing one  
10 connector assembly 505, as illustrated in Figure 12. Thus, the need to connect a separate power cord and plug to the power jack 575 is eliminated. Additionally, use of the alignment post 525 and locking latch 540 insures a secure connection between  
15 the connector plug and the corresponding jack.

It will be apparent to those skilled in the art that various modifications or variations may be made in the present invention without departing from the scope or spirit of the invention. Other embodiments  
20 of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein.